Hubble Space Telescope Servicing Lessons for In-Space Manufacturing

Rud Moe

GSFC

Brief Summary of HST Servicing

Mission	Accomplishments
HST SM-1	Optical correction, new upgraded science camera, upgrade computer, replace SA and electronics, gyros, magnetometer, add SI redundancy
HST SM-2	New IR and spectrograph science instruments, upgraded guidance sensor, solid state recorder, electronics and ORU replacements, new magnetometer cover, MLI repair
HST SM-3A	Emergency gyro replacement, new computer, added SSR, upgraded guidance sensor, transmitter replacement, MLI covers
HST SM-3 B	New science camera, cryo cooler and radiator for IR instrument, SA replacement, PCU replacement, RWA replacement, MLI covers
HST SM-4	2 new scien ce instruments, replace gyros, add radiator, replace batteries, upgrade guidance sensor, MLI covers, add data system redundancy

HST Servicing

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HST Servicing In-Space Manufacturing

Servicing Mission Manager's address to HST Servicing Mission Payload Operations Working Group regarding planning of contingency operations:

- "Don't get cocky…"
- "There's going to be a surprise; …and it's not the surprise you're thinking about!"

The first two HST Servicing Missions had surprises requiring in-space manufacturing as an impromptu contingency response

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SM-1 included the installation of a crew-built cover for the magnetometer

- Old magnetometer fell apart during installation of new magnetometer above it; exposed materials were a contamination threat to HST optics
- Ground Ops Team prepared a cover design and procedure overnight
- Crew commandeered MLI materials from carrier during next EVA
- Crew manufactured cover in middeck per instructions at end of EVA
- Crew installed new cover on next EVA

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SM-2 included the installation of a crew-built patches for the thermal blankets on forward shell/light shield and equipment bay doors

- HST hot side thermal blankets were found to be degraded, split, and curled in several places
- Ground Ops Team prepared patch designs and procedures overnight and next day
- Crew commandeered MLI materials from other contingency hardware provisions during following EVA
- Crew manufactured patches in middeck per instructions at end of EVA
- Crew installed new patches on subsequent EVAs

HST Servicing

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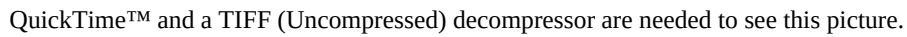

HST Servicing In-Space Manufacturing

Experience with earlier missions led to development of a contingency materials kit

- Mostly the kit contained additional blanket materials, tapes, cables, and clamps similar to the type previously used
- Other contingency provisions are difficult to conceptualize and justify
- Shop materials and parts for generic operations support

Specific contingency harware is developed and flown to address identified risks

- Tools, handling aids
- Braces
- Spare cables
- Replacement latches
- Spare ORUs

Servicing Challenges for In-Space Manufacturing

In-Space Fabrication capability could support more ambitious and complex assembly and servicing in space including contingencies

- Replacement of items damaged, lost, flawed, degraded, etc
- Too many sizes and types to supply
- Hard precision shaped items, fasteners, fittings, brackets, clamps, etc
- Compliant materials, springs, gaskets, clamp pads, etc
- Soft goods, blanket materials, etc
- Adhesives, lubricants, surface treatments, etc
- Fluid leak patches, hose connectors, etc
- Connector adapters, electrical parts, electronic devices, etc

Fabrication capability to control material properties is enabling